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ABSTRACT

This is one of five studies performed in 1976 to examine the characteristics of U.S. medical schools and the interrelationship among variables that describe them. A principal components analysis was performed and interpreted exploring the interrelationships of 33 selected variables that describe the faculty, student, curriculum, and other institutional characteristics of medical schools. A summary of the concepts underlying principal components analysis is presented, and the resulting factor pattern is presented and interpreted. Several speculative observations were made based solely on correlations in the data, and are suggested hypotheses for further analysis: (1) schools with an emphasis on graduate medical programs have proportionally fewer MD-program alumni going into general practice; (2) larger and older schools have proportionally more alumni receiving board certification; (3) private schools receive greater proportions of their revenue from gifts and federal sources; (4) schools with greater proportions of female students have a greater rate of approval of their NIH research grant proposals; (5) schools that have receieved larger increases in research funding between 1967 and 1974 tend to be the schools that anticipate the most growth in enrollment in the next five years; and (6) schools receiving the most research grants and expending the larger proportions of their budgets for sponsored research expend smaller proportions of their budgets for administration and general expense. (Author/MSE)

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A SECOND EXPLORATORY ANALYSIS OF THE RELATIONS AMONG INSTITUTIONAL VARIABLES

Charles R. Sherman, Ph.D.

FINAL REPORT

RELATED STUDIES

An Empirical Classification of U.S. Medical Schools by Institutional Dimensions

A Multidimensional Model of Medical School Similarities

Division of Operational Studies

ASSOCIATION OF AMERICAN MEDICAL COLLEGES

March 1977

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EXECUTIVE SUMMARY

A Second Exploratory Analysis of the Relations Among Institutional Variables is one of five studies performed in 1976 by the Association of American Medical Colleges (AAMC) to examine the characteristics of U.S. medical schools and the interrelationships among variables that describe them. Two of the five studies are replications of previous work. This report is one of three that present new explorations of AAMC's extensive institutional data base.

A principal components analysis was performed and interpreted exploring the interrelationships of 33 selected variables that describe the faculty, student, curriculum and other institutional characteristics of medical schools. The selection of 33 representative variables resulted from a series of preliminary analyses of 139 candidate variables from the four domains.

Among the variables involved were several measures that were not available for previous studies. These included characteristics of the careers of alumni and measures of traditional research grant application and funding success.

A summary of the concepts underlying principal components analysis is presented. The resulting "factor pattern" is presented and interpreted. Eight groupings of variables were observed that identify the eight basic dimensions of institutional variation in the 33 selected measures: graduate program emphasis, size and age, public vs. private control, minority orientation, research funding success, curriculum elective usage, current development, and research emphasis.

Several speculative observations were made based solely on correlations in the data. They may or may not be upheld, but it is the purpose of exploratory research to suggest hypotheses for further analysis. Among these.

- Schools with an emphasis on graduate medical programs have proportionally fewer MD-program alumni going into general practice.
- Larger and older schools have proportionally more alumni receiving board certification.
- Private schools receive greater proportions of their revenue from gifts and federal sources.

- Schools with greater proportions of female students have a greater rate of approval of their NIH research grant proposals.

- Curriculum information that is available concerns elective courses only and is independent of other institutional characteristics.

- Schools that have received larger increases in research funding between 1967 and 1974 tend to be the schools that anticipate the most growth in enrollment in the next five years.

- Schools receiving the most research grants and expending the larger proportions of their budgets for sponsored research expend smaller proportions of their budgets for administration and general expense.

Several questions and hypotheses are presented, based on the observed relations among the 33 variables and the eight basic dimensions.

Chapter I

INTRODUCTION

Background

In the process of carrying out its many activities, the Association of American Medical Colleges (AAMC) collects a variety of data from and about U.S. medical schools. For purposes of accreditation review, extensive quantitative information is received annually describing, in detail, the financial characteristics of each institution. The processing of applications for admission to medical schools contributes data about applicants that are accumulated and aggregated in ways that provide more institutional measures about applicants and, eventually, matriculants. In addition to the financial data, the Liaison Committee on Medical Education requests information about educational programs and detailed counts of students, faculty, and facilities. Information about the availability of elective courses are gathered to be published in the annual AAMC Curriculum Directory. These, together with additional data from occasional school surveys and other sources, are stored for ready retrieval in a computer based Institutional Profile System (IPS).

After the data have served their primary purposes they remain accessible for further analysis. In recent years the Bureau of Health Manpower (BHM) has sponsored a series of exploratory analyses to exploit the data to learn in what basic ways U.S. medical schools are similar and different and how schools would group together on the basis of their similarities. This is a report of the second in a series of original exploratory factor analyses. As planned, new (more recent) data were available for this study as well as several new measures. The purpose of the study is to examine the interrelationships of the currently available institutional measures, to speculate about common patterns of institutional functioning, and to add to the growing knowledge of what information may be contained in the rapidly expanding data base.

Overview

From an extensive data base of 600 variables, 140 potentially interesting variables were selected that describe faculty, student, curriculum and other institutional characteristics of U.S. medical schools. After a series of preliminary analyses and examinations for completeness, 33 variables were selected and submitted to a principal components analysis. From several resulting factor patterns, the most interesting was reported and interpreted as exposing eight basic dimensions of institutional variation that summarize the information in the 33 selected measures. Possible meanings of the association of individual variables with the eight dimensions are discussed.

Exploratory Objectives

While previous examples of the use of factor analysis from medical education literature have been presented elsewhere (Sherman, 1975), it may be well to review the objectives of this approach to data analysis. The goal of the present study is not to answer specific research questions by empirically testing formal hypotheses. The goal is, rather, to explore the available data for evidence of possible relationships that may exist among the categories of data descriptive of medical education. To do this one might consider examining the correlation coefficients describing each relationship between all pairs of variables. Given the large number of variables at hand (over 8000 when this study was begun), the problem of examining all such possible pairwise relationships is prohibitive. Assuming, however, that some form of structure exists among the complete set of intercorrelations of variables , and that the proper variables have been adequately measured, the task may be seen as a proper application for exploratory factor analysis. In the words of one of the pioneers of this method:

> When a particular domain is to be investigated by means of individual [for our purposes, "institutional"] differences, one can proceed in one of two ways. One can invent a hypothesis regarding the processes that underlie the individual ["institutional"] differences, and one can then set up a factorial

> experiment or a more direct laboratory experiment, to test the hypothesis. If no promising hypothesis is available, one can represent the domain as adequately as possible in terms of a set of measurements of numerical indices and proceed with a factorial experiment. The analysis might reveal an underlying order which would be of great assistance in formulating the scientific concepts covering the particular domain. In the first case we start with a hypothesis that determines the nature of the measurements that enter into the factorial analysis. In the second case we start with no hypothesis, but we proceed, instead, with a set of measurements or indices that cover the domain, hoping to discover in the factorial analysis the nature of the underlying order. It is this latter application of the factorial methods that is sometimes referred to as an attempt to lift ourselves by our own boot straps, because the underlying order in a domain cannot be discovered without first postulating it in the form of a hypothesis. This is probably the characteristic of factor analysis that gives it some interest as general scientific method. (Thurstone, 1947, p.55)

Henrysson (1960) adds that "explorative factor analysis is to be used primarily in the mapping of a field about which we have little knowledge or developed theories. The results of such analysis can then be used for formation of more rigorous hypotheses and in planning experiments" (p. 92). Mulaik (1972) also cites the value of exploratory factor analysis in generating hypotheses but acknowledges its limitations as a source of theory:

> Factor analysis can ultimately only provisionally establish its common factors as causal mechanisms accounting for the relationships among variables. Here factor analysis must give ground to experimental or observational techniques in which the researcher has direct control or observation of the crucial independent variables. Still one can think of many situations in the behavioral, social, and economic sciences in which direct control and observation of the crucial parameters are and will continue to be highly difficult to achieve, and it is in such situations that we expect factor analysis will continue to make valuable contributions (p.362).

Principal components analysis, the form of factor analysis performed in the present study, is essentially a way of grouping variables that tend to correlate with one another. The number of patterns of correlations within and among groups of variables is smaller and more manageable for examination, interpretation, and possible hypothesis generation than would be the full correlation matrix. As such it is ideally suited to overcoming the problem of "too much data" and meeting the present exploratory objectives.

The present use of exploratory techniques is not intended to imply that nothing is known about medical education. The present study serves to supplement other more focused "special studies" also performed by AAMC on various aspects of medical education.

Chapter II

METHOD

The method used to investigate the interrelationships about variables that describe the characteristics of medical schools may be described as three steps: selection of variables, factor extraction and rotation (principal components analysis), and interpretation of the resulting factor pattern matrix. These steps are described in this chapter.

Selection of Variables

As of August, 1976 over 8000 variables were contained in AAMC's Institutional Profile System. Many of them are repetitions of the same measure for several different years. Most of the distinct variables are gross counts, e.g., numbers of male students and numbers of female students, which, while conceptually different measures, are redundant in the way their values vary across institutions. Schools with relatively large numbers of male students by and large are the schools with large numbers of female students. More subtle measures of institutional characteristics, e.g., percentage of females among undergraduate medical students, are not contained in IPS. Such measures are more suitable for exposing institutional characteristics other than overall "size". A Researchable Data Base was constructed to include many newly computed comparative measures as well as a manageable subset of the most recent gross counts contained in IPS. Six hundred variables in the 1976 Researchable Data Base, then, served as the basis for the current series of exploratory analyses. Details describing the construction and make-up of the database are contained in a descriptive report by McShane (1977a).

From the variety of data elements available, 40 student, 22 faculty, 32 curriculum and 45 institutional measures were closely examined. (The initial 139 variables are listed in Appendix A.) It was desired to utilize variables that were fairly complete (having recorded values for nearly all schools) and representative of the principal dimensions of variation (among schools) in each ad hoc conceptual domain (faculty, students, etc.) This was accomplished through a preliminary series of correlational

analyses during which some variables were added, deleted, or substituted for one another. For example, in the selection of a variable to represent an institution's faculty pay scale, the original focus was on average salaries of faculties at the associate professor rank (strict full time) for all basic science faculty, all clinical science faculty and for one representative department from each area (department of anatomy, department of medicine). It was found that all four averages were highly correlated with one another. Data for all basic science faculty were more complete (104 schools reporting) than for clinical science faculty (87 schools), and both major groupings were more complete than the individual departments (56 schools each). Therefore the average salary for strict-full time basic science faculty was chosen to represent general pay scale in correlations with other variables.

Overriding the selection criteria described so far was a predilection for measures not available in earlier AAMC studies. In the final selection of 33 variables, eight were new. The eight newly available measures used are listed in Table 1. A complete list of the 33 selected variables, their means, standard deviations, and the number of schools for which data were available is given in Table 2. A glossary of abbreviations used is presented in Appendix B.

Principal Components Analysis

Principal components analysis is one of several data reduction procedures known generally as "factor analysis." The aim is to reduce the entire matrix of correlation coefficients between all pairs of variables into a smaller, more easily decipherable matrix without losing much of the information about how well pairs of variables are related. The smaller matrix of numbers, called a "factor pattern matrix," may be used to see how related variables may be grouped together and distinguished from less or unrelated variables.

In the present study the 33-by-33 matrix of correlation coefficients was computed allowing each coefficient to be based on as many paired observations as were available. Since some data were missing for some medical schools, different coefficients were based on somewhat

Table 1

Variables Not Available In Previous AAMC Exploratory Studies but Incorporated in the Present Analysis.

1. Percentage of living MD alumni in general practice.
2. Percentage of living alumni who are board certified.
3. Percentage of full-time and part-time faculty who are members of ethnic minorities.
4. Number of traditional single investigator research grants (R01's) approved in fiscal year 1975.
5. Percentage of all R01 grant applications approved in FY1975.
6. Percentage of R01 research dollars applied for that were awarded in FY1975.
7. Average standardized (within study group) priority score assigned to approved R01 grant applications.
8. Projected annual percentage change in first-year enrollment over the interval 1974-1979.

TABLE 2

MEANS, STANDARD DEVIATIONS, UNITS AND NUMBERS OF CASES
FOR 33 SELECTED MEDICAL SCHOOL VARIABLES

	VARIABLE	MEAN	STANDARD DEV	CASES	UNITS
INC058	RAT: MD STUDENTS TO FT FAC	1.7646	.8364	113	Student per faculty
STC043	RAT: HOUSESTAFF TO UNDERGRAD MD-STUD	.8342	.7222	114	Housestaff per student
VAR388	AV SALARY - SFT ASSOC PROF BASIC SCIENCE	24.8438	2.8588	104	Thousands of dollars
STC105	% LIVING MD-ALUMNI IN GENERAL PRACTICE	14.2884	7.1804	98	%
INC004	ADJUSTED TOTAL REVENUE	27177312.0000	17923088.0000	111	Dollars
VAR016	# MD-STUDENTS	474.3508	224.0000	114	Students
STC114	PROJTD ANNL % 1ST-YR ENROLL CHG: 1974-79	2.1664	5.3713	110	Annual % Change
VAR384	DHS GRANTS - # R01 APPS APPROVED	27.9123	21.5121	114	Applications
INC026	% EXPD FOR ADMIN & GENL EXPENSE	10.3282	5.7064	111	%
STC112	% LIVING MD ALUM BOARD CERTIFIED	45.9725	19.9767	98	%
INC003	DHS FED SPON RES CONS %CHG 67-9 TO 72-4	42.9654	107.1603	101	Annual % Change(const.$)
FAC019	RAT: VOL FAC TO FT FAC	2.3490	2.0885	111	Faculty per Faculty
INC017	% TOTAL EXPD FOR SPON RESEARCH	21.7811	12.2238	111	%
VAR394	1975-76 RESIDENT MD-STUDENT TUITION	2178.5356	1465.0522	112	Dollars
VAR002	CONTROL: 0 = PUBLIC; 1 = PRIVATE	.4017	.4924	117	Nominal (0, 1)
STC029	% IN-STATE 1ST-YR MD-STUD	74.5760	27.1324	112	%
STC094	RAT: APPLICANTS PER 1ST-YR MD-STUD	25.9356	16.3467	114	Applicants per student
INC007	% REV FROM FED SOURCES & RECOV INC COSTS	37.3254	13.1691	106	%
STC013	% 1ST-YR MD-STUD: PRE-MED GPA 3.6-4.0	37.6065	18.7109	113	%
INC012	% REV FROM ALL GIFTS	6.7409	5.6323	105	%
FAC001	% PT & FT SAL FAC WITH MD	62.9211	12.1226	114	%
STC082	% UNDERREP MINORITY 1ST-YR MD-STUD	9.4970	10.0717	102	%
FAC004	% PT & FT SAL FAC FROM ETHNIC MINORITIES	3.2585	10.5690	114	%
STC008	% NON US-CANADIAN 1ST-YR MD-STUD	1.2905	2.0513	113	%
VAR043	1ST-YR MD-STUD: MEAN MCAT SCIENCE SCORE	601.3145	34.7451	114	Points
INC046	NIH-NIMH R01 $ AWARD AS % OF $ APP SUBMT	26.3033	14.6229	114	%
INC045	IRG APPROVAL RATE OF NIH R01 COMP APPS	69.0138	21.9332	114	%
VAR352	IMPAC: MEAN STD P-SCR - R01 APP	.0821	.3337	107	Standardized Score
STC003	% FEMALE MD STUDENTS	18.6347	7.0418	114	%
CHC002	# OF HELATED ELECTIVES OFFERED	7.5812	4.0327	117	Elective Courses
VAR273	HEL ELECTIVES: ALCOHOLISM	.6283	.4854	113	Nominal(1 =available,0=NA)
INC048	LOG AGE OF MEDICAL SCHOOL	1.6367	.5536	117	Log(1976 minus year founded)
STC045	RAT: AMS GRAD-STUD TO UNDERGRAD MD-STUD	.2223	.1756	114	Student per Student

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17

different numbers of pairs. The diagonal elements in the correlation matrix contained "1's," the correlations of each variable with itself. The matrix was "factored" initially into 9 components (the number having eigenvalues greater than unity) accounting for 22.9, 11.4, 9.9, 7.1, 6.2, 4.9, 4.4, 4.2, and 3.4 percent of the variance in the full matrix. Separate varimax rotations were performed on the initial 9, 8, 7, 6, 5, and 4 components. Of these, the eight component solution, accounting for a total of 70.5 percent of total variance, had the most intuitive appeal and was chosen for closer examination, presentation and interpretation.

Interpretation of a Factor Pattern

A factor pattern matrix allows for variables that are interrelated to be grouped together and gives a numerical index of both how strongly a single variable belongs to a group and whether its association is positive or negative. With exceptions of occasional variables, groups are viewed as being conceptually independent of each other. Within this framework, the meaning of the several groups is hypothesized, and apparently misplaced variables give grounds for speculation.

An understanding of these concepts will be enhanced in the next chapter where the results of the present analysis are presented and discussed.

Chapter III

RESULTS AND DISCUSSION

Eight Component Factor Pattern

As a result of the procedures outlined in the previous chapter, eight numbers called "factor loadings" were derived for each of the 33 variables analyzed. The absolute value of the loadings represent the degree to which individual variables belong to each of eight groupings of variables. The set of factor loadings is arranged in a "factor pattern matrix" having one row for each variable and one column for each "principal component" or grouping of variables.

The eight component rotated factor pattern matrix is presented in Table 3. The rows of the matrix have been sorted to facilitate the identification of variables that grouped together on the basis of their intercorrelations. The large numbers (in absolute value) have been accentuated by "boxes," moderate values by asterisks. (To the right of each row is h^2, the communality of each variable, equal to the sum of the squared values in each row. These values reflect the degree to which the information carried by each variable is contained in all rotated components.)

As a preliminary example of the interpretation of the numbers in the matrix, consider the first row. "Average salary of strict-full-time associate professors in basic science departments" is seen as strongly related to the first group of variables since its value in the first column is large (.84). It is related to some general characteristic common to all variables in group one, perhaps an institutional emphasis on graduate medical programs. It is unrelated to the general characteristics underlying each of the other seven groupings since (looking across the first row) its "loadings" on those components are all nearly zero. Two other individual variables in the group (rows 3 and 5) are moderately related to other components (general characteristics), since they have secondary loadings in columns 8 and 3,

TABLE 3

EIGHT COMPONENT VARIMAX FACTOR PATTERN RESULTING FROM
PRINCIPAL COMPONENTS ANALYSIS OF 33 VARIABLES
DESCRIBING U.S. MEDICAL SCHOOLS

	VARIABLE	1 Graduate Medical Program	2 Size, Age	3 Control	4 Minority	5 Research Funding Success	6 Curriculum Electives	7 Developmt Stage	8 Research Emphasis	h^2
1	VAR388 AV SALARY - SFT ASSOC PROF BASIC SCIENCE	.84	-.02	.03	-.00	-.01	.05	.16	-.03	.73
2	STC043 RAT: HOUSESTAFF TO UNDERGRAD MD-STUD	.79	-.03	.19	-.03	-.00	.04	.05	.07	.68
3	INC058 RAT: MD STUDENTS TO FT FAC	-.67	.22	-.02	-.05	-.14	.05	.23	-.36*	.71
4	STC105 % LIVING MD-ALUMNI IN GENERAL PRACTICE	-.54	.33	-.13	.04	-.42*	-.24	.14	-.14	.70
5	FAC001 % PT & FT SAL FAC WITH MD	.40	.27	.33*	.06	.14	-.02	-.01	-.03	.37
6	VAR016 # MD-STUDENTS	-.09	.88	-.06	.03	-.04	.08	-.04	.16	.83
7	INC048 LOG AGE OF MEDICAL SCHOOL	-.28	.75	.21	.01	.15	.03	-.33*	.15	.83
8	STC112 % LIVING MD ALUM BOARD CERTIFIED	.14	.71	.42	-.17	.04	.07	-.28	.09	.75
9	VAR002 CONTROL: 0 = PUBLIC, 1 = PRIVATE	.15	.14	.87	.09	-.00	.03	-.13	-.01	.83
10	VAR394 1975-76 RESIDENT MD-STUDENT TUITION	.05	.13	.86	-.07	.13	.10	-.14	-.02	.82
11	STC029 % IN-STATE 1ST-YR MD-STUD	.01	-.06	-.81	-.23	-.14	.00	.18	-.16	.79
12	STC084 RAT: APPLICANTS PER 1ST-YR MD-STUD	.10	-.09	.79	-.03	.01	-.07	.27	-.03	.72
13	INC007 % REV FROM FED SOURCES & RCOV INC COSTS	.05	-.01	.48	.05	.22	.28	-.27	.48*	.66
14	INC012 % REV FROM ALL GIFTS	.20	.08	.38	.31	-.32	.10	-.06	.13	.33
15	STC087 % UNDERREP MINORITY 1ST-YR MD-STUD	-.04	-.09	.06	.94	-.10	.02	.06	-.03	.91
16	FAC004 % PT & FT SAL FAC FROM ETHNIC MINORITIES	-.11	-.06	-.04	.37	.03	.03	-.14	-.14	.82
17	STC008 % NON US-CANADIAN 1ST-YR MD-STUD	.19	.17	.25	.67	-.08	-.03	.06	.10	.60
18	VAR093 1ST-YR MD-STUD: MEAN MCAT SCIENCE SCORE	.43*	.23	.35*	-.44	.26	.04	.08	.36*	.75
19	INC046 NIH-NIMH R01 $ AWARD AS % OF $ APP SBMT	-.01	.11	.14	-.10	.84	.04	.07	.13	.77
20	VAR352 IMPAC: MEAN STD P-SCR - R01 APP	-.35	.04	-.09	.14	-.73	-.05	.21	-.05	.74
21	INC045 IRG APPROVAL RATE OF NIH R01 IMP APPS	-.04	.29	-.05	.01	.70	-.03	.22	.38*	.78
22	STC003 % FEMALE MD STUDENTS	.20	-.13	.18	.31	.48	.24	.02	-.28	.56
23	VAR273 REL ELECTIVES: ALCOHOLISM	.07	.03	-.01	.02	-.03	.88	.02	.03	.79
24	CRC002 # OF RELATED ELECTIVES OFFERED	.03	.14	.12	.01	.14	.82	.01	.24	.78
25	FAC019 RAT: VOL FAC TO FT FAC	-.12	-.02	-.02	-.11	.08	.10	.74	-.30	.68
26	INC003 DRG FED SPON RES CONS %CHG 67-9 TO 72-4	.14	-.44*	-.12	.15	-.01	.00	.73	.17	.82
27	STC114 PROJTD ANNL % 1ST-YR ENROLL CHG: 1974-79	.09	-.43*	-.17	-.04	-.01	-.09	.58	-.17	.60
28	VAR384 DRG GRANTS - # R01 APPS APPROVED	.41*	.41*	.05	-.01	.27	.05	-.03	.67	.87
29	INC026 % EXPD FOR ADMIN & GENL EXPENSE	.19	-.13	.02	-.13	.15	-.02	.25	-.64	.57
30	INC017 % TOTAL EXPD FOR SPON RESEARCH	.24	.13	.45*	-.02	.20	.26	-.04	.63	.78
31	STC045 RAT: BMS GRAD-STUD TO UNDERGRAD MD-STUD	-.05	.03	.09	-.09	.19	.23	.01	.61	.48
32	INC004 ADJUSTED TOTAL REVENUE	.43*	.52	-.01	.04	.16	.05	-.08	.57	.82
33	STC013 % 1ST-YR MD-STUD: PRE-MED GPA 3.6-4.0	.23	.02	-.06	-.19	-.04	-.05	-.04	.55	.40
	COLUMN SUM OF SQUARES	3.36	3.21	4.01	2.63	2.71	1.85	2.13	3.36	
	PERCENT OF VARIANCE	14.44	13.81	17.23	11.30	11.65	7.95	9.15	14.46	

respectively. Looking down Column 1, it can be seen that three additional variables from other principal components have secondary associations with an institution's graduate medical education emphasis. Additional instruction in the interpretation of entries in a factor pattern matrix is given in Appendix C.

The 33 variables formed eight groups that seem to reflect institutions' (1) graduate medical program emphasis, (2) size and age, (3) type of control (public versus private), (4) involvement of ethnic minorities, (5) research funding success, (6) use of electives in the curriculum, (7) stage of development, and (8) research emphasis. (The percentages of institutional variance in all eight components accounted for by each component is presented in the bottom row of Table 3. The percentages may reflect the relative degree of variation in each component, but they are affected to some degree by the numbers of variables in the groups.) Each of the eight groupings is discussed in the following sections. It should be kept in mind that the analysis is exploratory and that all interpretive observations are strictly tentative hypotheses.

(1) Graduate Program Emphasis

As characterized by the variables named in the first five lines of Table 3, the first principal component seems to describe the extent to which a medical school is involved in graduate medical education in addition to its undergraduate medical education program. Such schools may be typified by having a higher ratio of interns and residents to medical students, proportionally more faculty holding MD degrees, higher faculty salaries (in the basic sciences, but probably also in the clinical programs), and fewer (the loading is negative) undergraduate medical students per full-time faculty member. It may be interesting to note that relatively smaller proportions of former undergraduates from this type of institutional environment remain in general practice. Secondary factor loadings indicate that schools with a graduate program emphasis may tend to operate with larger budgets and have undergraduates with superior MCAT scores.

(2) Size and Age

The second component consists of three variables that are not strongly related to other components and four

additional variables that are shared. The essence of this grouping is that older schools tend to have larger undergraduate medical programs, larger budgets, and, interestingly, larger proportions of graduates who have become board certified specialists. The latter finding may be due in part to the fact that graduates from younger schools have had less time to achieve certification. Variables having secondary loadings on this principal component indicate that such older schools anticipate less growth in enrollment than do younger schools. They have not experienced the same proportional increases in federal sponsored research funding as have newer schools, yet they receive approval for larger numbers of research grants.

(3) Type of Control (Public versus Private)

The third principal component shows that several variables are related to whether a medical school is publicly or privately owned and controlled. Compared to public schools, private schools tend to have higher tuitions, enroll lower percentages of in-state resident students, process more applications for each opening, and receive greater proportions of their revenues from federal sources (a measure which includes the recovery of indirect costs) and from gifts.

A secondary loading indicates that private schools tend to expend greater proportions of their resources for sponsored research activity, much of which may be federally financed, thus partly explaining the disproportional income from federal sources. Another part of the explanation is the lack of income from state sources. In light of several other variables, however, research emphasis seems to be generally independent of type of institutional control.

(4) Involvement of Ethnic Minorities

Characteristics of medical schools currently enrolling proportionately more U.S. citizens from generally underrepresented ethnic backgrounds are shown in the fourth principal component. Such schools also have greater proportions of part-time and full-time faculties from minority backgrounds, greater proportions of non-U.S. and Canadian nationals, and students with lower average scores on the MCAT than have schools with less minority representation. It is not yet known to what

degree this component reflects the inclusion of data from the two historically Black medical schools, Howard and Meharry, and the University of Puerto Rico School of Medicine. Schools with generally higher levels of minority involvement are not distinguished by other characteristics defined by the other seven principal components.

(5) Research Funding Success

Four of the five variables (including one secondary loading) comprising the fifth component were "new" measures in the AAMC data base. Three pertain to applications for new single-investigator research ("R01") grants from NIH and NIMH, the fourth concerns alumni, and the fifth concerns female students.

Research proposals submitted to NIH for funding are reviewed by committees of other researchers (initial review groups) and approved or not on the basis of the scientific merit of the proposal. Those that are approved are assigned a "priority score," lower scores recommending greater priority to those who subsequently decide which projects will be funded. The institutional average priority scores used in this study are based on scores that had first been standardized by subtracting the mean and dividing by the standard deviation of all scores assigned by the initial review group to all approved applications from medical schools.

The fifth principal component in the present analysis shows that schools whose proposals have the highest rate of approval are schools whose approved applications also receive more favorable priority scores. The component also shows the natural corollary that the same schools, generally, are eventually awarded a greater proportion of the sum of dollars requested on all reviewed proposals. This characteristic dimension of institutional differences is apparently independent of other measures of research emphasis, the eighth principal component, discussed below.

The exploratory analysis result presents two unexpected correlates with success rate in research funding. Schools with better rates of funding success apparently tend to be schools with greater proportions of female undergraduate students. They also tend to have smaller percentages of alumni in general practice. It is difficult

to know what to say about these findings without looking for additional correlates. Upon re-examination of a preliminary analysis conducted as a part of the variable selection process, positive correlations were found between percentage female students and both percentage female faculty and percentage of all sponsored research that is funded by NIH. It could be envisioned that, given equivalent merit and quality of proposals, NIH gave some preference to female investigators. The linear correlation between percentage female faculty and R01 approval rate, however, is only +.25.

(6) Electives in the Curriculum

The sixth principal component, consisting of only two variables, indicates only that schools reporting the availability of relatively more elective courses, including one that covers alcoholism, are not also distinguished by any of the institutional characteristics described by other principal components. As was noted in an earlier study, (Sherman, 1975), the AAMC data base contains very little information about content of educational programs in medical schools. It has also been noted that components consisting of very few variables may be unreliable (Sherman, 1977).

(7) Stage of Development

Three variables, one each from the student, faculty, and institutional descriptive domains grouped together, forming a seventh principal component that may distinguish developing from established medical schools. A fourth variable, the age of the school, has a secondary loading on this component. If this model is justified, developing schools are seen to be younger, utilize larger proportions of volunteer faculty, and project larger increases in enrollment than do other schools. Developing schools have also experienced relatively larger proportional increases in federally sponsored research revenues in recent years (1967 through 1974) than have more established schools. It may be interesting to note that the ratio of volunteer faculty to salaried full-time faculty appears to be more strongly related to a development component than to graduate medical program emphasis (component 1) as may have been expected. As discussed above, the two percentage change measures have secondary loadings on the "size and age" component (number 2).

(8) Research Emphasis

Extent and emphasis of sponsored research activity seems to be the common theme of variables loading on the last principal component. Six variables are primarily related and four variables have secondary loadings on this component. Three of the primary variables are also related to other principal components and are discussed above in other contexts.

Schools with a research emphasis may be characterized by relatively high percentages of budgets expended for sponsored research, large numbers of research grants approved, high ratios of basic medical science graduate (M.A. and Ph.D.) students to undergraduate (M.D.) medical students, high percentages of students with superior pre-medical grade point averages, and low percentages of expenditures for administration and general expense. Some of the inverse relationship observed between research and administration expenditure percentages is artifactual, since they are percentages of the same total. It may be hypothesized, however, that above a certain level of activity, additional sponsored research does not add noticeably to administrative expenses. Adjusted total revenue is related to the extent of sponsored research as well as to the sizes of the graduate and undergraduate medical programs. Schools with a research emphasis tend to report more faculty per student and greater percentages of revenue from federal sources (including the recovery of indirect costs). They have students with higher academic qualifications (in terms of MCAT scores and GPA's) and somewhat better than average rates of approval of their "R01" research grant proposals, though the latter seems more strongly related to proxy measures of quality of the research proposals (component 5, discussed). Few of these observations are surprising and tend, rather, to affirm confidence in the available data.

Chapter IV

CONCLUSION

Caveat

This study, like other studies in the series, was exploratory, designed to stimulate hypotheses rather than to answer specific questions. The method used was predominantly objective but also somewhat restrictive in its assumptions and subjective in its application. In view of these conditions, any observations must be considered tentative and best expressed as questions or hypotheses about medical education institutions, and, occasionally, about the data collected to study their operations.

Observations

A clear pattern emerged from a principal components analysis of 33 selected variables. While individual variables may be related to more than one component, the eight components may be hypothesized to be functionally independent. For example, whether or not a medical school has a graduate medical education program may be independent of the school's age, whether it is public or private, and whether it places strong emphasis on research. The eight components discernable in the patterns of variation in the particular variables selected are (1) graduate medical programs, (2) size and age, (3) type of control, (4) ethnic minority involvement, (5) research funding success, (6) curricular offering of electives, (7) stage of development, and (8) research emphasis.

Some observed relationships and anomalies may merit further investigation with appropriate data transformations and quasi-experimental controls. Are medical schools with graduate programs unduly, even inadvertently, encouraging specialization to their undergraduate students? Are graduates of older and larger schools more likely to achieve board certification? If so, why? What is the direct or indirect relationship between the presence of females and a school's research funding success rate? Is there a ceiling to incurred indirect costs when sponsored research activities are expanded?

A dearth of quantified data about curricula was noted. The feasibility of adding comparative curricular information to the database may be worth exploring.

The emergence from this study of an apparently more sensible pattern than those achieved in studies using older data may evidence improvements in data acquisition and quality control.

Further Studies

Based on the findings of this study, several additional examinations of the data can be envisioned and some are already being performed.

Some studies could be designed to focus on individual relationships between pairs of variables, with extra care given to data transformations and possible covariates.

For each school, factor scores can be computed to establish each school's location on the dimensions described by each component. Such scores are being used by McShane (1977b) to cluster similar schools into natural, empirical groupings.

It was noted that graduate medical program emphasis and research emphasis are distinct components of medical school operations. A school may be characterized by having one, both, or neither of these emphases. Or they may possess either emphasis to some degree. As was suggested in an earlier study, it may be meaningfully descriptive to answer the question "How are schools distributed on a plane whose two axes are 'research emphasis' and 'health care delivery [or graduate medical program] emphasis'?" (Sherman, 1975, p. 62). A study which attempts to answer this question is currently underway at AAMC.

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Appendix A

Initial 139 Variables Selected
for Exploratory Analysis

STUDENT VARIABLES

1.	VAR016	# MD-STUDENTS
2.	VAR088	1ST-YR MD-STUD: OVERALL GPA
3.	VAR090	1ST-YR MD-STUD: MCAT VERBAL SCORE
4.	VAR093	1ST-YR MD-STUD: MCAT SCIENCE SCORE
5.	VAR094	1ST-YR MD-STUD: AVERAGE AGE
6.	STC001	% FEMALE 1ST-YR MD STUDENTS
7.	STC003	% FEMALE MD STUDENTS
8.	STC008	% NON US-CANADIAN 1ST-YR MD-STUD
9.	STC013	% 1ST-YR MD-STUD: PRE-MED GPA 3.6-4.0
10.	STC015	% 1ST-YR MD-STUD: PRE-MED GPA < 2.5
11.	STC025	% 1ST-YR MD-STUD: MASTERS OR PHD
12.	STC029	% IN-STATE 1ST-YR MD-STUD
13.	STC032	% 1ST-YR MD-STUD WITHDREW, ACADEMIC
14.	STC038	% 1ST-YR MD-STUD WITHDREW, ALL
15.	STC041	% MD-STUD WITHDREW, ALL
16.	STC042	# POST-GRAD MD-STUD - HOUSESTAFF
17.	STC043	RAT: HOUSESTAFF TO UNDERGRAD MD-STUD
18.	STC045	RAT: BMS GRAD-STUD TO UNDERGRAD MD-STUD
19.	STC052	% HOUSESTAFF POSITIONS UNFILLED
20.	STC053	% FMG HOUSESTAFF
21.	STC054	# HOUSESTAFF POSITIONS
22.	STC057	% MD-STUD APPLY FIN AID
23.	STC063	% ALL APPLICNTS REC FIN AID FR MED-SCH
24.	STC073	$ AWARDED PER MD-STUD REC AID
25.	STC082	% UNDERREP MINORITY 1ST-YR MD-STUD
26.	STC083	% FOREIGN NATIONAL 1ST-YR MD-STUD
27.	STC084	RAT: APPLICANTS PER 1ST-YR MD-STUD
28.	STC087	RAT: MINORITY APP PER MIN 1ST-YR MD-STUD
29.	STC090	% UNDERREPRESENTED MINORITY APPLICANTS
30.	STC091	% FEMALE APPLICANTS
31.	STC092	% IN-STATE APPLICANTS
32.	STC094	DIFF: MEAN MATRIC-MEAN APP AGE
33.	STC095	DIFF: MEAN MATRIC-MEAN APP OVERALL GPA
34.	STC096	DIFF: MEAN MATRIC-MEAN APP SCIENCE GPA
35.	STC097	DIFF: MEAN MATRIC-MEAN APP MCAT VERBAL
36.	STC100	DIFF: MEAN MATRIC-MEAN APP MCAT SCIENCE
37.	STC105	% LIVING MD-ALUMNI IN GENERAL PRACTICE
38.	STC112	% LIVING MD ALUMNI BOARD CERTIFIED
39.	STC113	% ACT LIV MD ALUM ON FAC OF OTHER MD-SCH
40.	STC114	PROJTD ANNL % 1ST-YP ENROLL CHG: 1974-79

FACULTY VARIABLES

1.	VAR151	# FT BAS SCI FAC
2.	VAR158	# FT CLINICAL FACULTY
3.	VAR166	# PART TIME PT FACULTY IN MED-SCH
4.	VAR167	# VOLUNTEER VOL FACULTY IN MED-SCH
5.	VAR388	AV SALARY - SFT ASSOC PROF BASIC SCIENCE
6.	VAR389	AV SALARY - SFT ASSOC PROF CLINICAL SCI
7.	VAR390	AV SALARY - SFT ASSOC PROF MEDICINE
8.	VAR391	AV SALARY - SFT ASSOC PROF ANATOMY
9.	FAC001	% PT & FT SAL FAC WITH MD
10.	FAC002	% PT & FT SAL FAC WHO ARE FMG'S

Appendix A (Continued)

11.	FAC003	% PT & FT SAL FAC WHO ARE FEMALE
12.	FAC004	% PT & FT SAL FAC FROM ETHNIC MINORITIES
13.	FAC005	% PT & FT SAL FAC: IN-BRED MD
14.	FAC008	RAT: BAS SCI FT FAC TO CLIN FT FAC
15.	FAC010	ANNUAL PT & FT FAC TURNOVER RATE
16.	FAC011	% FT BAS SCI FAC ASSOC PROF & ABOVE
17.	FAC012	% FT CLIN FAC ASSOC PROF & ABOVE
18.	FAC015	% VACANT BAS SCI FAC POSITIONS
19.	FAC016	% VACANT CLIN FAC POSITIONS
20.	FAC017	RAT: FT FACULTY TO MD STUDENTS
21.	FAC018	RAT: PT FAC TO FT FAC
22.	FAC019	RAT: VOL FAC TO FT FAC

CURRICULUM VARIABLES

1.	VAR269	SPEC ADVISORY PROGRAMS FOR DISADV MD-STU
2.	VAR270	MD-STUD RET ACT: TUTORING BY FACULTY
3.	VAR271	MD-STUD RET ACT: TUTORING BY MD-STUD
4.	VAR272	FORMAL PROG FOR PHD SEEKING MD
5.	VAR273	REL ELECTIVES: ALCOHOLISM
6.	VAR274	REL ELECTIVES: BIOMEDICAL ENGINEERING
7.	VAR275	REL ELECTIVES: COMMUNITY MEDICINE
8.	VAR276	REL ELECTIVES: DRUG ABUSE
9.	VAR277	REL ELECTIVES: EMERGENCY MEDICINE
10.	VAR278	REL ELECTIVES: ETHICAL PROBLEMS IN MED
11.	VAR279	REL ELECTIVES: GERIATRICS
12.	VAR280	REL ELECTIVES: HEALTH CARE DELIVERY
13.	VAR281	REL ELECTIVES: HUMAN SEXUALITY
14.	VAR282	REL ELECTIVES: MEDICAL HYPNOSIS
15.	VAR283	REL ELECTIVES: MEDICAL JURISPRUDENCE
16.	VAR284	REL ELECTIVES: NUTRITION
17.	VAR285	REL ELECTIVES: PATIENT EDUCATION
18.	VAR286	REL ELECTIVES: POPULATION DYNAMICS
19.	VAR287	REL ELECTIVES: PRIMARY CARE
20.	VAR288	CURR INNOV: CLINICAL APPL OF COMPUTERS
21.	VAR289	CURR INNOV: COMPUTER ASSISTED INSTRUCT.
22.	VAR290	CURR INNOV: AMBULATORY CARE PROGRAM
23.	VAR293	GRADING: LETTER-NUMBER GRADES
24.	VAR295	CURR ADM: CURR EVALUATION COMM.
25.	VAR297	# MONTHS REQUIRED TO COMPLETE MD - MIN
26.	VAR301	COMBINED MD-PHD PROGRAM
27.	VAR302	MD PROGRAM FOR PHD'S - REDUCED TIME
28.	VAR305	# OF REQUIRED CLERKSHIPS
29.	VAR306	FAMILY MED TRNG PROG FOR UNDERGRAD MD-ST
30.	VAR307	OTHER PRIMARY CARE PROGRAM FOR UG MD-STUD
31.	VAR308	MD-STUD REQUIRED TO TAKE NBME-1
32.	VAR309	MD-STUD REQUIRED TO TAKE NBME-2

INSTITUTIONAL VARIABLES

1.	VAR002	CONTROL: 0 = PUBLIC, 1 = PRIVATE
2.	VAR180	# DEANS APPOINTED, 1960-1976
3.	VAR248	# BEDS AVAILABLE FOR CLINICAL EDUC.
4.	VAR251	# OUTPAT VISITS PER YEAR: ALL CLIN FACIL
5.	VAR352	IMPAC: MEAN STD P-SCR - R01 APP
6.	VAR353	IMPAC: SD STD P-SCR - R01 APP
7.	VAR384	DRG GRANTS - # R01 APPS APPROVED
8.	VAR386	DRG GRANTS - $ AMT OF R01 APPS AWARDED

Appendix A (Continued)

9.	VAR394	1975-76 RESIDENT MD-STUDENT TUITION
10.	INC001	RAT: POP IN SMSA TO MD-STUD IN SMSA
11.	INC002	LCME FED SPON RES CON $ % CHG 67-9 TO 72-4
12.	INC003	DRG FED SPON RES CON $ % CHG 67-9 TO 72-4
13.	INC004	ADJUSTED TOTAL REVENUE
14.	INC007	% REV FROM FED SOURCES & RCOV INC COSTS
15.	INC008	% FEV FROM TUITION & FEES
16.	INC012	% REV FROM ALL GIFTS
17.	INC013	% REV FROM STATE GOVERNMENTS
18.	INC01[illegible]	% SPONSORED RES REV FROM FED GOVT
19.	INC01[illegible]	% TOTAL EXPD FOR SPON RESEARCH
20.	INC018	% REV FROM INDIRECT COST RECOVERY
21.	INC019	% REV FROM PROFESSIONAL FEES
22.	INC020	% EXPD FOR MED INSTR & DEPT RES
23.	INC022	% EXPD FOR OTHER SEP BUDGETED RES
24.	INC023	% REV FOR SPONS TCH-TRN
25.	INC024	% EXPD FOR MULTI-PURPOSE & SERVICE PGMS
26.	INC025	% EXPD FOR OPER & MAINT OF PHYS PLANT
27.	INC026	% EXPD FOR ADMIN & GENL EXPENSE
28.	INC027	% SPONS PGM EXPD FROM FEDS
29.	INC029	% SPONS PGM EXPD FROM NON-GOVT
30.	INC03-	% FED SPONS RES $ FROM NIH
31.	INC035	# OWNED OR AFFIL CLINICAL FACILITIES
32.	INC036	RAT: $ EXPD PER FT FACULTY
33.	INC037	RAT: PROFESSIONAL FEES PER FT CLIN FAC
34.	INC038	RAT: AVAIL TCHNG BEDS PER MD-STUDENT
35.	INC039	RAT: SPONS PGM EXPD PER FT FAC
36.	INC038	RAT: MD STUDENTS TO FT FAC
37.	INC059	RAT: TOTAL STUDENTS TO FT FAC
38.	INC043	REG OPER EXPD: TOTAL MINUS SPONSORED
39.	INC044	RAT: REG OPER EXPD PER MD-STUDENT
40.	INC045	TRG APPROVAL RATE OF NIH R01 COMP APPS
41.	INC046	NIH-NIMH R01 $ AWARD AS % OF $ APP SBMT
42.	INC047	AVERAGE $ AWARD PER R01 APP APPROVED
43.	INC048	LOG AGE OF MEDICAL SCHOOL
44.	INC054	% EXP FOR SPONSORED PROGRAMS
45.	INC057	RAT: REG OPER EXPD PER FT FAC

APPENDIX B

Abbreviations Used in 1976
Researchable Data Base Variable Labels

$	Dollars
#	Number
%	Percent
% Chg	Percent Change
A-Health	Allied Health
Accel	Accelerated
Act	Avcite, Activity
Adm	Administration
Admin & Genl	Administration & General
Admt	Admitted
Adm-Pref	Admittance-Preference
Adu Stdg	Advanced Standing
AEC	Atomic Energy Commission
Affil	Affiliated
Agrmt	Agreement
Alum	Alumni, Alumnae
Amer	American
Amt	Amount
Annl	Annual
App	Applications, Applicant
Applicnts	Applicants
Apply	Applying
Appr	Appropriations
Assist	Assistant (ASST)
Assoc	Associate
Avail	Available
Av	Average
BA	Bachelor of Arts
Bas	Basic (Sciences)
Bal	Balance
BHRD	Bureau of Health and Resources Development
BMS	Basic Medical Sciences
BS	Bachelor of Science
Budg	Budget(ed)
Bus & Ind	Business and Industry
Ch	Choice
Chg	Change
Clin	Clinical (Sciences)

APPENDIX B (Continued)

Coll	College
Comm	Committee
Comp	Competing
Con$	Constant Dollars (adjusted for inflation)
Curr	Curriculum
Def	Deficit
Deg	Degree
Dept	Department (al)
DHEW	Dept. of Health, Education and Welfare
Diff	Difference
Dir	Direct
Disadv	Disadvantaged
Dist	Distributed
DOD	Dept of Defense
DRG	Division of Research Grants (NIH)
Ed	Education, Educational (Educ)
Elec	Electives
Emerg-Med	Emergency Medicine
Endow	Endowments
Enroll	Enrollment
Equivs	Equivalents
Exp	Expenditures (Expd)
Fac	Faculty
Facil	Facility
Fed	Federal
Fem	Female
Fin	Financial
Fin-Yr	Final Year
FMG	Foreign Medical Graduate
Fr	From
FT	Full Time
Gen	General
Govt	Government
GPA	Grade Point Average
Grad	Graduate
GT	Greater than
HMO	Health Maintenance Organization
IMPAC	DRG's computer file of grants & contracts

APPENDIX B (Continued)

Incl	Including
Indir	Indirect (Ind)
Innov	Innovations
Instr	Instructor
Instrct	Instructional
Intrn	Interns
IRG	Initial Review Group (study section)
LCME	Liaison Committee on Medical Education
Liv	Living
Log	Logarithm
LT	Less Than
Matric	Matriculant
MCAT	Medical College Admissions Test
MD-Stud	Medical Student
Med	Medical
Med-Sch	Medical School
Mid-Yr	Middle Year
Min	Minority
Mnlnd	Mainland
MS	Master's degree
Multi-Purp	Multi-Purpose (MP)
Multi-Serv	Multi-Service
NBME-1	National Board Medical Examiners (test) - Part I
NBME-2	National Board of Medical Examiners - Part II
NIH	National Institutes of Health
NIMH	National Institute of Mental Health
Non-Govt	Non-Governmental
Non-Res	Non-Resident
NSF	National Science Foundation
Oper & Maint	Operation and Maintenance
Org	Organized, Organizational
Outpat	Out patient
P-Scr	Priority Score
PØl	Program and Project Grants
Phys	Physical
Pop	Population
Pos	Position
Post-Docs	Post-Doctorates
Post-Grad	Post-Graduates
Prac	Practice

APPENDIX B (Continued)

Pre-Med	Pre - Medical
Priv	Private
Prof	Professional
Prog	Program (Pgm)
Projtd	Projected
PT	Part Time
Pub	Public
Quant	Quantitative
RØl	Traditional Research Grants
Rat	Ratio
Rec	Received
Recov	Recovery (RCOV)
Reg Oper Expd	Regular Operating Expenditures
Rel	Related
Res	Research
Resrv	Reserves
Ret	Retention
Rev	Revenues
Rsdnt	Resident
Sal	Salary
SBMT	Submitted
Sch	School
Sci	Science
SD	Standard Deviation
Sep	Separately
Serv	Service
SFT	Strict Full Time
SMSA	Standard Metropolitan Statistical Area
Spec	Special, Specialty
Spons	Sponsored
Sq	Square
St & Loc	State and Local (S&L)
St Rel	State Related
Std	Standardized
Stud	Student
Tch-Trn	Teaching and Training
Tchng	Teaching
Tot	Total
Undergrad	Undergraduate (Ungrad, UG)

APPENDIX B (Continued)

Underrep	Under-represented
Unk	Unknown
Unrestr	Unrestricted
US-Can	United States and Canadian
Vol	Volunteer
Yr	Year

APPENDIX C

Interpretation of the Factor Pattern Matrix

An understanding of the interpretation of the numerical "loadings" that comprise the factor pattern matrix facilitates the assessment of the results the factor analysis used for exploratory purposes.

The numbers in a table of "factor loadings" are measures of strength of association between the variables and the derived "factors". Like correlation coefficients representing the relationship between pairs of simple variables, they range in value from +1.0 to -1.0. Values near zero represent "no relationship"; values near +1.0 or near -1.0 represent strong positive and strong negative relationships respectively. The first row shows how strongly the first variable is related to each factor. Because of the rotational criterion, any one variable is probably highly related to only one or two factors and weakly related, at best, to the other factors. For purposes of speculation it is assumed that variables related to the same factor are likely to be related to each other.

For ease of examination, the variables in the table are often ordered according to their highest factor loadings. The predominant loading (or loadings) for each variable are highlighted with a "box" (for high values) or an "asterisk" (for moderately high values). The grouping of variables means that they may be related to one another, that is, their values vary the same way across institutions. At any given school, high standardized values of one variable tend to be matched with high values of the other, low with low, if the relationship is positive, that is, if the signs on the loadings are the same (both "plus" or both "minus"). If the signs of two variables' loadings are different (one "plus" and one "minus") the relationship is probably negative, that is, high standardized values of one variable are matched with low values on the other. Because the factors are numerically independent of one another (due to the rotational procedure used), it is also likely that the variables in one group have low correlation with variables in another group. Exceptional variables are readily seen.

By way of additional guidance in the interpretation of the factor pattern matrices, two additional rules of thumb may be useful. First, factor loadings with value less than

APPENDIX C (Continued)

about .50 (in absolute value) should not be given as much attention as larger numerical loadings. Second, variable groupings that account for small percentages of overall variance (given at the bottom of each column) may be less accurate indicators of potential relationships than groupings accounting for greater percentages of variance.

Whereas the named "factors" may be conceptually or mathematically independent and most variables related only to one factor, some individual variables may be found to be related to more than one factor. This may be more easily understood through a simple analogy. If, instead of medical schools, rectangles were the unit of study, their height, width, and area might be among the measured variables. As a result of analysis, height and width may be found in a common factor with area, but, since height and width are independent of each other, one or both may also be found in additional factors (variable groupings).